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Trace element behavior in prograde high temperature metapelites: Insights from garnet mapping from the Ivrea-Verbano Zone, Italy

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Trace element (TE) zoning patterns in garnet can be used to interpret high to ultra-high temperature (HT-UHT) processes occurring in the mid-lower crust. This is owed to the slower diffusivities of trace elements compared to major elements [1]. This study investigates the two-dimensional distribution of TE in garnet (LA-ICP-MS mapping) from a prograde metapelitic sequence and employs a multi-mineral TE approach to assess micro-scale geochemical mobility and its influence on the whole-rock budget. The study focuses on the Permian lower continental crustal section, the Ivrea-Verbano Zone (IVZ), in NW Italy. The supracrustal rocks of the Kinzigite Formation in the IVZ preserves a continuous metamorphic field gradient from the amphibolite to granulite facies [2]. This makes it an exceptional natural setting to study the systematic behavior of TE. The study aims to establish whether garnet is adjusting its composition by diffusion or recrystallisation in the presence of partial melts.

Garnet is the primary host for Y+HREE in the metapelites – exhibiting distinct zoning patterns at both metamorphic facies, with homogeneous garnet only observed at UHT conditions. The complex TE zoning of amphibolite-facies garnet is not preserved at granulite facies, where garnet has a smooth bell-shape zoning in Y+HREE. TE with even slower diffusivities than REE, such as Zr, V, Cr display varied zoning in garnet. The TE zoning suggests that granulite-facies garnet grew peritectically via melting reactions that consumed biotite (Bt + Qtz + Pl + Sil = Grt + Kfs + Rt + melt). Mass balance calculations support V and Cr redistribution from biotite in amphibolite facies to garnet and rutile in granulite facies. Zr content in garnet shows a consistent increase with metamorphic grade, and at UHT the high Zr (~300 ppm) suggests garnet recrystallisation. We conclude that the observed zoning in garnet and the TE redistribution in the metapelites result from a dynamic interplay of processes such as Rayleigh fractionation, breakdown of mineral phases and peritectic growth. Melt-assisted recrystallisation is effective in erasing the history of sub-solidus garnet growth.

[1] Bloch, E. M. et al. (2020) J Petrol **61(7)**
[2] Redler, C. et al. (2012) JMG **30**, 235–254